CHAPTER 4. HABITAT EVALUATION

Part Two: Biological Effects of Programmatic Actions

Chapter 3 evaluated the existing state of environmental pathways and indicators important to the survival and recovery of ESA-listed and candidate fish species, relative to ESA standards for these key pathways and indicators. This chapter examines the likely biological effects of flood and erosion hazard reduction activities conducted since 1993 on the existing condition of these pathways and indicators, focusing on the direction of change, if any, which will occur because of these actions. It should be understood that this assessment is broad and programmatic in scope, not a detailed reach-by-reach or project-by-project analysis.

As stated in Chapter 1, virtually all of the River Management Program's flood and erosion hazard reduction activities can be grouped into several major elements:

- *Structural Capital Improvement Projects (CIPs)*. This element focuses on building projects to reduce flood hazards along the major rivers in King County. These include building new levees and revetments; major modifications to existing facilities (e.g., freeboard increases and set backs); and reconnecting off-channel habitats with main river channels. Since the 1970s, no truly new CIPs have been constructed or installed along reaches of riverbank where no such structures were previously present. River Management Program staff have indicated that it is unlikely that any new facilities will be constructed in the future. Since 1990, virtually all of these projects have emphasized biotechnical approaches involving the installation of large woody debris and vegetation.

- *Relocation and Elevation Projects*. This program element implements the relocation and elevation of homes and businesses in flood prone and erosion hazard areas as a long-term cost-effective solution to repetitive flooding problems. Acquisition and relocation can refer to either demolition of a flood-prone structure and relocation of its residents, or actual relocation of the structure. Some of these projects have included floodplain habitat restoration.

- *Maintenance and Monitoring*. Historically, major maintenance activities consisted primarily of replacing riprap eroded by the river and clearing vegetation. This approach was costly, and since it often did not address the cause of the damage, had to be repeated frequently. The new approach emphasizes more environmentally friendly bioengineering methods (soil biostabilization) such as vegetative brush layering to stabilize riverbank and levee slopes, and toe-buttress construction with large stone and firmly anchored LWD emplacements at the base of a facility. These actions are designed to improve instream habitat along the toe of the facility and to minimize the potential for flood-flow undercutting, erosion, and sloughing of the face of the facility. Maintenance and monitoring also encompasses such routine maintenance activities as inventories of facilities, mowing of invasive non-native plant species on levee slopes, mowing for flood patrol access, access control and maintenance, control of invasive plants on newly-vegetated facility repair sites, irrigation, hazard tree removal, partial logjam removal or relocation, and gravel bar removal. The monitoring portion of this element involves monitoring the results or effects of various River Management Program activities with adaptive management activities and projects where warranted.

- *Complaint Response and Enforcement*. This program element does not involve construction projects. Rather, it only identifies and tracks potential problems related to rivers and flood facilities. Recommendations for action are implemented under other program elements.

- *River Planning*. This program element does not involve construction projects. It is solely concerned with planning activities such as floodplain modeling and mapping, channel migration studies and mapping, sediment transport studies, fish habitat studies, river greenway plans, and dam operation studies. Recommendations for action are implemented under other program elements.

- *Flood Hazard Education*. This program element is solely concerned with educating the public about flood hazard and river safety issues.

- *Flood Warning and Emergency Response*. This program is concerned with warning King County and local emergency response agencies, riverside residents, and the general public of impending flood events in major rivers so appropriate actions can be taken. It also encompasses such activities as emergency repair of bank erosion, emergency levee and revetment repair, emergency logjam relocation or removal, and distribution of sandbags in situations where flooding poses an imminent threat to public safety and infrastructure.

- *Interagency and Inter-local Coordination*. This program element is focused on enhancing coordination among the counties, cities, and other regulatory jurisdictions that share various overlapping responsibilities for all aspects of flood control across King County's river basins.

Actions taken under these programs could have one of three possible outcomes on environmental pathways and indicators. They can (1) restore, (2) maintain, or (3) degrade the existing environmental baseline conditions. Programmatic actions can also affect environmental pathways and indicators through (1) direct (2) indirect (3) cumulative (4) interdependent and/or (5) interrelated effects. Distinctions between these are largely legalistic. Programmatic actions can also have adverse effects or beneficial effects. These various kinds of effects are discussed in the second part of this chapter.

It is also important to note that programmatic actions may produce effects over the short-term, long-term or both—and that short-term effects may be different from long-term effects. Although difficult to define precisely, river ecologists generally accept "short-term" to be a time frame of days to months, and "long-term" to be a time frame of years to centuries (Swanston 1991; Imhof et al. 1996; Montgomery and Buffington 1998). Programmatic actions could also manifest over different spatial scales. These vary from strictly site-specific (where the effect could be on localized flows, microhabitats, or individual channel units), to reach scale (where the effect could be on many channel units or on the structure, mobility, and function of the channel itself), to the entire length of the stream (Frissell et al. 1986; Imhof et al. 1996; Montgomery and Buffington 1998).

In this context of effects occurring over a range of spatial and temporal scales, it has been observed that streams impacted by urban land uses generally do not stabilize to their altered condition until the level of land use has remained constant for one to several decades (Leopold 1973; Riley 1998; Finkenbine et al. 2000; Hartley et al. 2001 and Finkenbine et al. 2001). This generalization is also consistent with the results of Harding et al. (1998) who found that the best predictors of fish and invertebrate diversity in streams (indicators of stream condition) were the level and type of watershed land use that occurred four decades earlier. It is likely, then, that a similar lag time, on the order of one to several decades, will be observed before the beneficial effects of corrective programmatic actions will be fully realized.

LIKELY EFFECTS OF PROGRAMMATIC ACTIONS ON ENVIRONMENTAL PATHWAYS AND INDICATORS

Basic Conflicts between Flood/Erosion Control and Essential Habitat for Listed Species

Before considering the individual environmental pathways and indicators, there are two overarching biological effect issues that arise out of a fundamental conflict between <u>any</u> flood and erosion control program and the essential habitat needs of listed and candidate species. These are discussed here for listed chinook salmon where the essential habitat need may be spawning habitat, and for candidate coho salmon where the essential habitat need may be off-channel habitat for winter rearing.

As described in Chapter 2, chinook salmon may be spawning habitat limited because of their strong tendency to aggregate or cluster in certain areas while ignoring other superficially similar areas (Vronskiy 1972; Healey 1991; Geist and Dauble 1998). Preferred chinook spawning areas typically form where, on the reach scale, the river is quite dynamic, i.e., where deposits of gravel and coarse sediment force the channel to split, braid, or anastomose. Because these are the same areas often mapped as channel migration hazard zones, these are also the areas most constrained from migrating by the past construction of training levees and revetments, and the maintenance of these facilities, to protect roads, houses, farms, or developments. Such constraints can thus restrict the amount of preferred chinook spawning habitat available in the reach, and prevent the river from forming new potential spawning habitat for chinook.

Also noted in Chapter 2 were important chinook spawning-cluster areas that have been identified at the following locations in King County rivers:

- South Fork Skykomish River: Tye RM 71-73; Beckler RM 3-5; Miller RM 0.5 (SBSRTC 1999; WDFW and WWTIT 1994a; Williams et al. 1975)

- Snoqualmie River: mainstem RM 22-25; RM 34-35; Raging RM 0-4 (SBSRTC 1999; WDFW and WWTIT 1994a; Williams et al. 1975).

- Cedar River: RM 6-7; RM 10-11; RM 13-19 (Mavros et al. 2000; WDFW and WWTIT 1994b.

- Green River: mainstem RM 29-30.5; Soos Creek RM 0-6 (Grette and Salo 1986; WDFW and WWTIT 1994b; Williams et al. 1975).

- White River: spawning-cluster areas have not been identified in this system (Ladley et al. 1996; WDFW and WWTIT 1994b).

While chinook salmon spawn in other areas, the identified areas should be considered the essential habitats remaining within the programmatic action areas. These areas should receive special attention for protection—they could even be considered the *core conservation areas* for chinook. These areas are highlighted in Folio Maps 4-1 – 4-7.

In contrast to chinook, coho salmon are not usually limited by the availability of spawning habitat. Because coho spawn in the same split, braided, and anastomosed reaches used by chinook, they can also be adversely affected by projects affecting these habitats. Coho adults also commonly spawn in accessible small tributaries (Sandercock 1991). Because juvenile coho rear in streams for a full year, the limiting factor for coho is usually the availability of suitable rearing habitat—both for summer rearing and, perhaps more importantly, for the critical overwintering period. Juvenile coho show a general preference for slow-moving pools, and actively defend territories in pools during the summer. They also occupy deep pools with gravel or cobble substrate that they use for cover during the overwintering period. Levees and revetments confine the channel and often lead to increased water velocities that eliminate pools and turn affected reaches into uniform, featureless glides of little habitat value to the fish (Dillon et al. 1998). Perhaps more than any other salmonid species, juvenile coho also utilize off-channel ponds and wetlands, side channels, back channels, and springbrooks during the overwintering period (Sandercock 1991). Access to these critical habitats is often eliminated by the construction and maintenance of levees and revetments (Perkins 1993, 1996; Dillon et al. 1998).

The critical habitat needs for listed bull trout appear to be clean, cold water for spawning, and a cold water temperature regime for successful incubation, both of which are found only upstream of King County's flood control facilities. However, since bull trout must pass through these lower river reaches on their way to and from spawning and incubation areas (at least they do in the South Fork Skykomish and White Rivers), resting pools for upstream migrating adults, and stream-margin habitats that can shelter downstream-migrating juveniles could be negatively affected by flood and erosion control actions.

Since interstitial spaces within riprap are used to some extent by juvenile salmonids, not all rearing habitat is lost when flood and erosion control projects are constructed (Dillon et al. 1998). Various methods of bank stabilization influence local fish abundance differently (Li et al. 1984; Knudsen and Dilley 1987; Lister et al. 1993; Beamer and Henderson 1998; Peters et al. 1998). Overall, the loss of pool habitat and off-channel habitats for overwintering greatly overrides the habitat gained along riprap (Dillon et al. 1998).

Appendix F contains the NMFS's Matrix of Pathways and Indicators used to evaluate the effects of programmatic actions. It should be noted that neither NMFS nor USFWS guidelines require restoring environmental pathways and indicators to fully pristine, pre-settlement conditions. Rather, the intent is to move the indicators in a positive direction to facilitate the recovery of listed species. Thus, a checkmark in the Restore column means that the programmatic action will move that indicator toward a more properly functioning condition but not necessarily to a pre-development state.

Table 4-1 summarizes the likely effects of King County River Management Program's flood hazard reduction programmatic actions on the environmental pathways and indicators identified in Chapter 3. As noted above, there may be a lag time on the order of decades to attain full results.

Environmental Pathways and Indicators—Water Quality

Temperature. As discussed in Chapter 3, water temperature is an important factor that influences migrations, spawning, and rearing of listed and candidate salmonids. Each fish stock has a unique time and temperature pattern to maximize the survival of offspring in its particular setting. Because most anadromous stocks have evolved with the temperature patterns of their home streams, significant abrupt deviations from normal patterns can adversely affect fish survival (Bell 1986; Bjornn and Reiser 1991).

In the short term, programmatic actions will have minimal affects on existing summer water temperatures in King County rivers. In the longer term, it is possible that summer temperatures may decrease slightly as a result of improved shade provided by trees and shrubs planted at project sites.

Sediment/turbidity. Programmatic actions, such as bank stabilization activities, may produce short-term effects in King County rivers by mobilizing minor localized amount of fine sediments during the construction period. This can produce short-lived elevated levels of suspended sediment and increased turbidity near these projects. Some King County River Management Program actions will undoubtedly occur in or near reaches that contain spawning habitat. Other sites contain rearing and transportation habitat for chinook and coho salmon. A few sites on South Fork Skykomish and White Rivers also provide transportation but not spawning or rearing habitat for bull trout. Fine sediment deposition into spawning habitat downstream from project sites may reduce salmonid reproductive success by decreasing oxygen penetration into the interstitial spaces within redds, and/or by physically trapping incubating salmonid eggs and alevins. The release of fine sediment during project activities into rearing and transportation habitat could also adversely affect the gill surfaces of salmonids, interfering with respiration. It could also decrease light penetration into the water column, making it harder for juvenile fish to locate and successfully consume food resources. It could also disrupt or delay upstream migration of adult salmonids, and/or cause juvenile salmonids to temporarily leave the area during instream construction activities. Sand-size sediment may also contribute to pool-filling downstream from project sites, thereby decreasing rearing habitat and resting-pool volume, at least until the first freshet in the fall. The magnitude of sedimentation from the projects proposed and implemented by the River Management Program since 1993 is nowhere near as severe, for example, as that mobilized by hydraulic dredging. Fine sediment deposition could also disrupt benthic invertebrate production downstream from some project sites, thereby reducing the local food supply for salmonids, but would be unlikely to be disruptive at other sites where the existing riverbed substrate composition (sand and silt) typically produces very low populations of large macroinvertebrates (Gore 1978).

In the long term, chronic streambank failures related the accelerated rates of fine sediments and their instream deposition may be decreased. With that, the potential for remobilization of fine sediment and accompanying increased turbidity levels because improved levee and revetment configurations should increase resistance to streambank sloughing. Increased amounts of vegetation on streambanks from programmatic actions will also reduce fine sediment.

Chemical contaminants/nutrients. Properly functioning riverine ecosystems have low chemical contamination, and generally, low to moderate levels of nutrients. High levels of chemical contaminants such as metals, hydrocarbons and pesticides reduce egg and alevin survival and are toxic to juvenile and adult salmonids. Even low concentrations of such substances can induce physiological stress in fish, alter primary and secondary production of streams, and reduce biodiversity (Seiler 1989, Karr 1991, Nelson et al.1991, Norris et al. 1991). All King

Table 4-1. Matrix of Pathways and Indicators—Effects of Programmatic Actions

PATHWAYS AND INDICATORS	SHORT TERM EFFECTS			LONG-TERM EFFECTS		
	Restore	Maintain	Degrade	Restore	Maintain	Degrade
WATER QUALITY:						
Temperature		X		X		
Sediment			X	X		
Chemical Contaminants/ Nutrients		X		X		
HABITAT ACCESS:						
Physical Barriers	X			X		
HABITAT ELEMENTS:						
Substrate		X		X		
Large Woody Debris	X			X		
Pool Frequency	X			X		
Pool Quality	X			X		
Off-channel Habitat	X			X		
Refugia	X			X		
CHANNEL CONDITIONS & DYNAMICS:						
Width/Depth Ratio		X			X*	
Streambank Conditions	X			X		
Floodplain Connectivity	X			X		
FLOW/HYDROLOGY:						
Peak/Base Flows		X			X	
Drainage Network Increased		X			X	
WATERSHED CONDITIONS:						
Road Density & Location		X		X		
Disturbance History		X			X	
Riparian Reserves		X		X		

For the purposes of this checklist, "Restore" means to change the condition of an At Risk or Not Properly Functioning indicator for the better. "Maintain" means that the function of an indicator will not be changed. "Degrade" means that the condition of an indicator will change for the worse.

** The Green River, in particular the lower Green River, as "maintain." It is highly unlikely that the condition of this indicator for the lower Green River will change.*

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County rivers within the King County River Management Program receive inputs of numerous nonpoint sources of chemical contamination and nutrients. This includes stormwater runoff from urbanized landscapes, nutrients from agricultural areas and golf courses, and fine sediment from runoff upstream of the action area evaluated under this study from heavily logged upper watershed catchments.

Because the programs addressed in this evaluation largely consist of modifications and retrofits to existing flood control facilities, no increases in current levels of land development are anticipated because of these projects. Thus, no short term changes in inputs of chemical contamination or nutrients are expected because of River Management Program actions. In the long term, these programs are likely to result in modest and localized decreases in chemical contamination and nutrients due to (1) localized decreases in soil slumping and erosion, (2) localized deposition of river-borne sediments, and (3) increased localized uptake of nutrients by maturing native riparian vegetation installed at program sites, especially willows planted along the lower bank line.

Environmental Pathways and Indicators—Habitat Access

Physical barriers. The usual application of this indicator is related to anthropogenic blockages such as dams, screens, water diversion structures or flap gates that block fish migration. Blocking culverts in tributaries are also included in this indicator. Another important aspect of this indicator is access to off-channel habitats that could be use by rearing juvenile fish. Flood and erosion control projects often eliminate access to these critical habitats (Perkins 1993, 1996; Dillon et al. 1998). Overall, the loss of critical off-channel habitats for overwintering coho juveniles, and the loss of back channels and the side channels that occur in braided and anastomosed reaches that are important for early rearing of juvenile chinook in streams, overrides the small amount of habitat contributed by riprap (Dillon et al. 1998).

Programmatic actions to buy out and remove structures in the floodplain, plus companion programs to remove and set back levees and revetments where possible and to reconnect blocked habitat areas, should have beneficial effects on this indicator in both the short and long term. King County River Management Program staff have already implemented these types of projects and identified many other such opportunities. None of the programmatic actions would degrade mainstem physical access. Some currently planned and future projects would improve access to off-channel habitats.

Environmental Pathways and Indicators—Habitat Elements

Substrate. In a properly functioning river system, sediment and its transport from source to downstream reaches is an important process that affects and maintains salmonid habitat. Suitably sized, clean gravel provides a quality substrate for salmon egg incubation, food source production and protection from predators. Disruption of sediment recruitment and transport by impoundments, channel diversions, mass wasting and pervasive bank erosion often degrades fish habitat. Chronic erosion of fine bank sediments and their instream deposition can reduce egg and alevin survival in spawning reaches, reduce primary and secondary productivity, and interfere with feeding, behavioral avoidance and social organization (Bisson and Bilby 1982; Berg and Northcote 1985; Everest et al. 1987; Chapman 1988). Sediment from mass failures and landslides can result in these same effects, as well as fill in pools and induce channel migration (Beschta 1978; Cederholm et al. 1981; Everest et al. 1987; Swanson et al., 1987, Chapman, 1988).

Over the short term, actions by the River Management Program will maintain current substrate conditions. Over the long term, as installed vegetation matures, trapping of fine sediment from slumps and runoff from upland source areas should increase incrementally at project sites, and substrate conditions downstream of these sites could result in incremental improvements.

Large woody debris (LWD). Instream LWD is a critical component of salmonid habitat (Swanson and Leinkaemper 1978; Bryant 1983; Harmon et al. 1986; Gregory et al., 1991; Peters et al. 1998; Bilby and Bisson 1998). NMFS (1996) considers 80 pieces per mile as a minimum for a Properly Functioning Condition. This would equate to approximately 15 logs per 1000 feet.

As shown in Table 1-4, River Management Program projects typically add on the average of 49 pieces per 1000 feet of coniferous LWD (18 inches minimum diameter and 25 feet minimum length) and additional deciduous LWD at some projects. This modest increase in volume of LWD within programmatic action areas would be realized in both the short and long term. However, these projects cannot and will not fully restore LWD to the NMFS (1996) target levels along the entire reaches of King County rivers because of existing land use constraints including trails, roads, bridges, and the presence of residential and commercial buildings in many developed locations. Although these projects will provide for some degree of future LWD recruitment as tree plantings mature, they will not fully restore functioning riparian forests for future LWD recruitment adjacent to project sites. Typical placement of LWD - predominately along channel edges - will not recreate the same types of large, complex, hydraulically dynamic log jams that were present historically and led to the formation of large, deep high quality mid-channel pools.

Pool frequency. Through the placement and orientation of LWD, there would likely be a modest increase in pool frequency related to programmatic actions. This could occur even in the short term as the streams interact with the installed structures. Again, these projects will not fully restore pool frequency to Properly Functioning Condition within the overall action area because of existing land-use constraints, including trails, roads, bridges, and the presence of residential and commercial buildings in many developed locations.

Pool quality. Programmatic actions will result in modest, localized improvements in pool quality through the addition of LWD in various configurations. These configurations include coniferous log flow deflectors with rootwads, coniferous logs with rootwads placed parallel to the bank with rootwads facing upstream, whole deciduous trees placed parallel to the bank with rootwads facing upstream, and one or both of these elements in combination with moderately complex arrays of logs placed in eddy pools. In addition, numerous coniferous and deciduous trees will be planted in order to provide for future recruitment of LWD into the rivers. The volumes of wood installed and trees that eventually mature at these sites will improve pool quality in the near and long term, but may not fully restore this indicator to properly functioning level for the reasons cited above in the discussion of the LWD indicator. This is especially in the Green River, where extensive channelization of the river has occurred and the extent of urban development within the adjacent riparian zone limits reestablishment of natural channel morphology.

Off-channel habitat. The importance of off-channel habitat has been discussed in several places in this report. Through implementation of the proposed programs, existing off-channel habitat may be made more accessible to fish. Programmatic actions to buy out and remove structures in the floodplain, plus companion programs to remove and set back levees and revetments where possible and to reconnect blocked habitat areas, should have beneficial effects over both the short and long term.

Refugia. Refugia are habitats or environmental factors that convey spatial and temporal resistance and resilience to biotic communities impacted by biophysical disturbances (Sedell et al. 1990). Mainstem pools, for example, can offer pockets of cooler water that provide thermal refugia for migrating adult chinook and other salmonids (Berman and Quinn 1991; Fresh et al. 1999). As noted earlier, riprap, such as what currently exists on many River Management Program facilities, can provide some habitat for juvenile fish including interstitial spaces that these fish can use as refugia against high flows (Dillon et al. 1998). It should be noted that this habitat is of variable quality (Li et al. 1984; Knudsen and Dilley 1987; Lister et al. 1993; Beamer and Henderson 1998; Peters et al. 1998). The installation of LWD and vegetation may locally and incrementally restore more viable refuge associated with riparian structure along the mainstem riverbanks, and increase potential pool formation. This could increase this indicator rating in both the short and long term.

Environmental Pathways and Indicators—Channel Condition and Dynamics

Reintroducing natural rates of channel migration and associated erosion of floodplain lands may become feasible in some King County rivers as future programmatic decisions are planned, funded and implemented to relocate or remove existing roads, trails, bridges, residential and commercial buildings presently situated in channel migration hazard zones and 100-year floodplains. While such programmatic actions may create temporary adverse impacts on other pathways and indicators, the condition and dynamics of the channel should increase in the long term.

Width/depth ratio. The numeric criterion of <10 established by NMFS (1996) for this indicator to be in Proper Functioning Condition is inappropriate for large, low-gradient alluvial streams such as the lower Green and lower Snoqualmie Rivers. Well-functioning riverine habitats in low-gradient alluvial reaches such as these likely had much higher width/depth ratios in pre-development times. Thus, while the channel form of these streams is technically in accordance with NMFS (1996) criteria, the authors do not believe that this indicates a Proper Functioning Condition. Land use constraints prevent anything beyond a very modest alleviation of channel constrictions at many sites, and may preclude it at other sites along the lower Green River. Though minor widening may occur through levee setbacks and mid-slope benching, programmatic actions will essentially maintain existing width-depth ratios. In other King County rivers, there is more flexibility for programmatic actions to improve this indicator rating; such improvements should be expected as a long-term outcome.

Streambank condition. Streambank stability is currently Not Properly Functioning at many failing bank locations within programmatic action areas because of over steepened banks with little if any woody vegetation. Programmatic actions to help restore streambank conditions include (1) decreasing the slope angle to the maximum extent practicable given existing land use constraints, and (2) increasing the aerial coverage of the riverbank by woody vegetation, thereby increasing soil cohesiveness and bank structural integrity. In addition, revegetation will induce greater volumes of fine sediment deposition onto setback benches and reconfigured slopes, which will in turn induce accelerated growth of native riparian species planted during these projects and those that colonize onto these sites naturally. Improvements in this indicator could occur in both the short and long term.

Stream buffers. While facility repairs using vegetative methods will not themselves restore significant tracts of riparian forest, growth of planted riparian trees and shrubs will modestly restore stream buffers at these sites over the next several decades. More substantial improvements in riparian zones can be expected to occur at sites where levees and revetments are relocated or removed.

Floodplain connectivity. Because of levees and revetments already in place, linkages of wetlands, floodplains, and riparian areas to the main channels have been reduced to varying degrees in all King County rivers. Programmatic actions to buy out and remove structures in the floodplain, plus companion programs to remove and set back levees and revetments where possible and to reconnect blocked habitat areas, should have beneficial effects on this indicator in both the short and long term. King County Flood Hazard Reduction Services Section staff have already completed some of these projects and identified many other similar opportunities.

Environmental Pathways and Indicators—Flow/Hydrology

Change in peak/base flows. Programmatic actions will have no short or long term effect on the volume of peak and base flows or flow timing in King County rivers.

Drainage network increase. This indicator addresses increases to the natural drainage network of a river or stream brought about by road building or artificial drainageways such as ditches, culverts, retention/detention ponds, stormwater pipes, and the like. Programmatic actions evaluated in this assessment are expected to have little affect on this indicator in either the short or long term.

Environmental Pathways and Indicators—Watershed Conditions

Road density/location. Existing road densities in King County programmatic action areas generally range across the spectrum from greater than to less than three lineal road miles per square mile. Moreover, many roads closely parallel streambanks in all of these areas.

While programmatic actions will have no effect on existing or future road densities, these actions could have a beneficial long-term effect on the location of roads. This could occur directly through the *Relocation* program element, where roads in flood prone and erosion prone locations are relocated or removed such as occurred on Russell Road near RM 18.6 in the Green River. Floodplain and channel migration zone regulations could also require alternative locations for new roads and currently require zero-rise encroachment and compensatory flood storage. The location of roads could also occur through the Flood Hazard Reduction Plan's *River Planning, Flood Hazard Education,* and *Interagency/ Interlocal Coordination* program elements where threats to public health and safety and costs of ill-advised road location could be highlighted and emphasized.

Disturbance history. All King County rivers have a history of watershed disturbance resulting from the progression of land uses that has occurred. This includes conversion from forestry to agriculture to urbanization and industrialization, and other anthropogenic channel alterations, water diversion, and dams. While it is unlikely that the programmatic actions will return any of the King County rivers to Properly Functioning Condition, they will incrementally improve local habitat conditions in the long term, thereby modestly decreasing disturbances to riverine ecosystems, particularly in rural corridor areas where acquisition and home relocation activities result in reclaimed natural floodplain areas.

Riparian reserves. Programmatic actions will modestly restore riparian habitat conditions in the long term, particularly at project that setback or remove levees. It is unlikely that fully functional riparian habitats will be restored because of constraints of existing land use that are beyond the control of the Rivers Program.

Direct, Indirect, and Cumulative Effects of Programmatic Actions

Direct Effects of Program Elements

Of the program elements whose effects on environmental pathways and indicators were evaluated above, the four listed below include activities that will have direct effects on listed and candidate fish species either during construction or in later operation:

- Structural Capital Improvement Projects (CIPs).
- Major and routine maintenance.
- Relocation and elevation projects.
- Emergency response.

Direct effects during construction. The construction of CIPs, major and routine maintenance, and emergency response projects could result in episodic, short-term disturbances from operation of heavy equipment below the ordinary high water level. Activities such as the placement of toe rock and LWD may cause temporary increases in suspended solids loads, turbidity, and sedimentation downstream during construction.

Juvenile chinook, coho, or bull trout rearing in or migrating through King County rivers as well as adult fish migrating to spawning areas could be impacted by projects through noise, fine sediment pulses, turbidity, or other activity. Spawning areas downstream of projects could also be impacted by depositions of fine sediment. Observations during ten years of constructing these projects on all the large rivers in King County (King County 2001) found that while juvenile fish move away from project sites during active construction, they move back to the sites quickly amidst newly installed logs. This often occurred even during brief cessation of construction activities (e.g., during 15 minute breaks). Since migrating adult salmon generally do not feed, delays during migration can deplete their limited energy reserves, thereby increasing the possibility of mortality, and reducing spawning success. Such migration delays would be of short duration, and generally limited to daylight hours on weekdays when construction crews are present.

Temporary sediment and turbidity pulses during construction are not expected to translate downstream from site to site; nor is it expected that cumulative effects will accrue at a series of projects located downstream. For this reason, it is unlikely that fish, if temporarily displaced from one site, would encounter another site subject to similar, simultaneous disruption. An exception to this supposition may be early migrating adult chinook that could sequentially encounter several sites over the course of passage to upstream spawning areas. It is likely that the bulk of upstream migration will occur during cooler, darker evening and nighttime hours when construction is not active.

Many of these direct effects during construction can be minimized or mitigated by scheduling work during windows of time when migrating and spawning adults are not present, and when peaks of juvenile migration are not likely to occur. All work areas, except the riverward ends of log trenches and where toe rock will be installed, can be isolated from surface flows. Other BMPs, including placement of floating turbidity curtains to sequester any observed plumes of silt throughout the duration of inwater construction, and all other known and reasonable techniques can be used to greatly minimize erosion and control sedimentation during construction.

Direct effects during operation. Long-term effects of programmatic actions undertaken in the CIP and major maintenance program elements may have beneficial effects once in operation because such projects usually result in a decrease in suspended solids and sedimentation (Stern and Stern 1980). Over time, the low benches, LWD, shade trees, and overhanging vegetation installed at these project sites will provide a modest amount of hydraulic refuge during winter flood events. Velocities near the woody debris and the benches will be less than further out into the channel. The pool-forming potential of LWD placement will provide both rest stops and thermal refugia for migrating adults and additional rearing habitat for juveniles.

The Routine Maintenance and Emergency Response program elements were not included among those affording direct benefits because routine maintenance, as described by the King County River Management Program (King County 1993) includes a limited amount of partial logjam relocation and removal and gravel bar removal. These activities seldom benefit fish in the long-run. However since 1993, the River Management Program has not done any logjam relocation or gravel excavation. The Flood Hazard Reduction Plan policies narrowly limit the conditions under which logjam relocation and gravel excavation will be allowed and will continue to impose impediments to these activities in the future. Emergency Response typically implies that one fixes the problem on the spot as best one can, which is not likely to benefit fish even in the short term. Follow-up actions to address such impacts will be consistent with the discussion above for major maintenance.

Indirect Effects

Indirect effects are those that occur because an action has been taken, but not as an immediate or direct result of the action. As described in Chapter 1, programmatic actions will not entail building new facilities, nor will facility expansion occur either upstream, downstream or waterward into the river channel. Therefore, programmatic actions are unlikely to create conditions that will increase the number or incidences of future activities that could affect listed, proposed, or candidate species. For this reason, no indirect effects are foreseen for chinook and coho salmon and bull trout.

Cumulative Effects

Cumulative effects are those that accrue or add to a programmatic action. For example, adding to effects produced by future federal, State, or private activities of a like kind that may occur within the action area. A schematic diagram, drawn from Appendix I of the Tri-County Urban Issues ESA Study (R2 Resource Consultants et al. 2000), shows the cumulative effects of channelizing and diking programmatic actions (Figure 4-1). It is not anticipated that the programmatic actions evaluated here will increase the number or incidences of future activities that could accumulate effects on listed, proposed, or candidate species. No adverse cumulative effects are foreseen for chinook and coho salmon and bull trout.

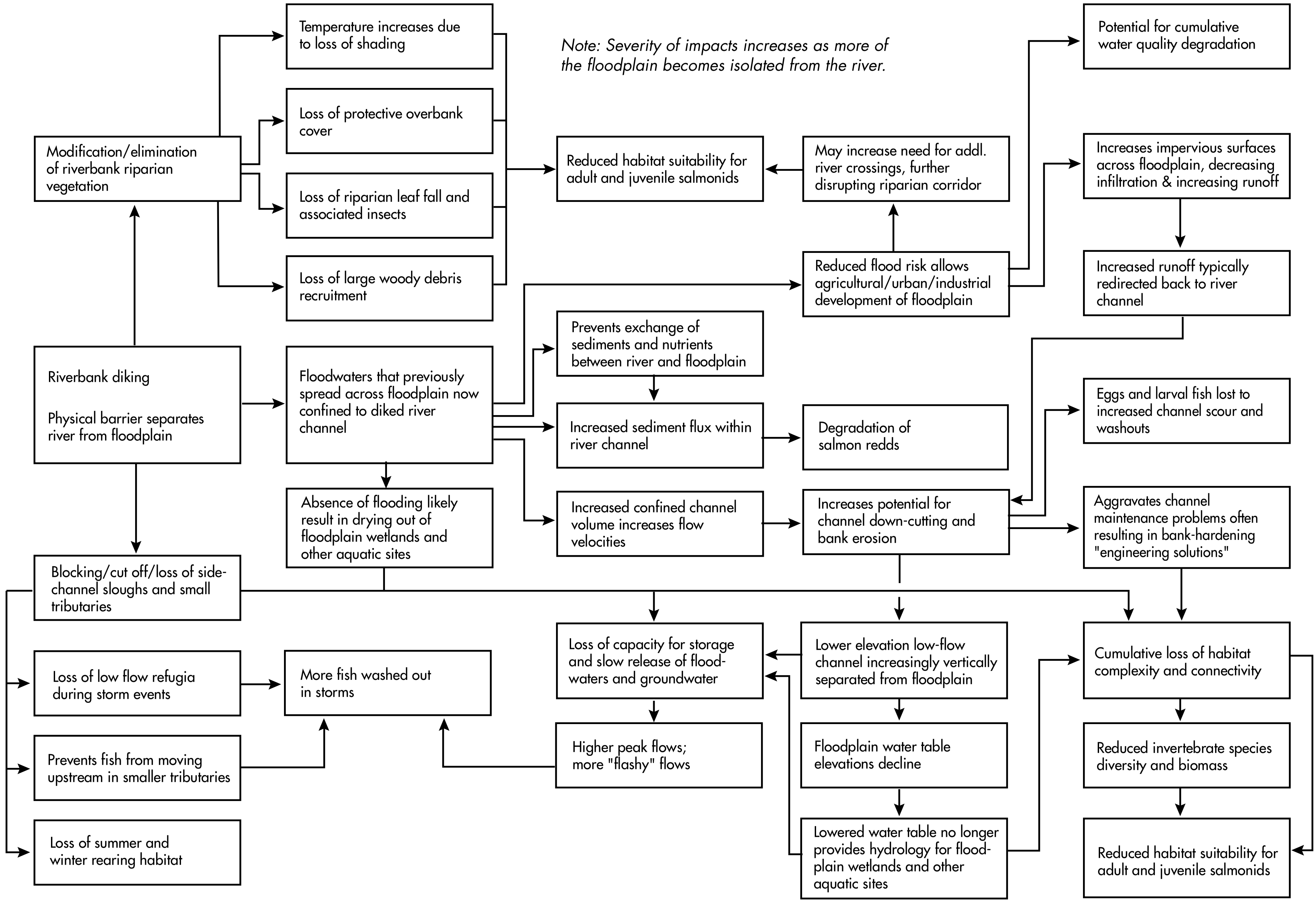

Figure 4-1
Cumulative effects of channelization and diking on salmon habitat (MacDonald, CH2M Hill 2000)

Developed after Beechie at al (1994), Gore & Shields (1995), Spence et al (1996), RSRWQ (1996), Riley (1998).

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WLRD Visual Communication & Web Unit

Beneficial Effects

By themselves, actions taken under the Program Elements considered here will not return King County rivers to Properly Functioning Condition listed in the *Matrix of Pathways and Indicators* guidelines in either the short or long term. At the same time, the programmatic actions will not likely further degrade the river systems. These actions will do as much as is reasonably possible at each site to address historic degradation and move these pathways and indicators back in the right direction. In the long term, programmatic actions will likely result in an:

- Increase overall bank stability, thereby decreasing accelerated rates of erosion and bank slumping that contribute to turbidity and sedimentation problems.

- Modest increase the mean size, frequency and complexity of LWD in channels within action areas.

- Modest increase the amount of sediment depositional areas outside the immediate channel in setback bench locations, which will improve instream conditions.

- Modest increase the amount, variety, and availability of cover and refuge habitat for salmonids along the channel margins over a range of discharges.

- Modest increase the type, amount, extent, and variety of native riparian vegetation through replacement of existing stands of invasive exotic, non-native species such as blackberries and reed canarygrass.

- Modest increase the amounts of overhanging vegetative cover, allochthonous inputs, nutrient uptake and denitrification, terrestrial insect production, and LWD recruitment sources, due to plantings of native vegetation above the OHWM along the length of project sites.

- Modest improvement in upstream and downstream migration habitat for listed and candidate salmonids, as well as rearing and flood refuge habitat.

- Modest decrease in chemical contamination and nutrient inputs to streams through (1) localized decreases in soil slumping and erosion, (2) localized deposition of river-borne sediments, and (3) increased uptake of nutrients before they reach streams by maturing native riparian vegetation installed at program sites.

- Increase in access to off-channel rearing habitat in both the short and long term through actions (1) to buy out and remove structures in the floodplain; (2) to remove and set back levees and revetments where possible; and (3) to reconnect blocked habitat areas.

- Modest improvement in substrate condition in the long term as installed vegetation matures and trapping of fine sediment from slumps and runoff from upland source areas occurs.

- Modest increase in pool frequency and pool quality through the placement of LWD. This could occur both short and long term as the streams interact with the installed structures.

A further and vitally important beneficial effect may be realized by: (1) identifying important areas of chinook spawning, such as those shown on Folio Maps 4-1 through 4-7; and (2) removing, to the extent possible, anthropogenic constraints on the channel's ability to move and thereby replenish and revitalize these habitats. This can be done through programmatic actions in the Relocations and Elevations Program Element and through Structural Capital Improvement Projects that assist the river in accessing historic side channels without creating new flood hazard problems.